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Scandinavian Journal of Information Systems

Volume 3 | Issue 1 Article 3

1991

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Recommended Citation
Lyytlnen, Kalle (1991) "PENETRATION OF INFORMATION TECHNOLOGY IN ORGANIZATIONS: A Comparative Study Using Stage Models and Transaction Costs," *Scandinavian Journal of Information Systems*: Vol. 3 : Iss. 1 , Article 3.
Available at: http://aisel.aisnet.org/sjis/vol3/iss1/3

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Scandinavian Journal of Information Systems, Vol. 3, pp. 87–109, 1991

PENETRATION OF INFORMATION TECHNOLOGY IN ORGANIZATIONS

A Comparative Study Using Stage Models and Transaction Costs

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Abstract

Since the late 60's information systems (IS) research has been concerned with the problem of how the penetration of information technology (IT) into organizations can be understood and explained. The article maps out two classes of models explaining the IT penetration: evolutionist stage-models and evolutionary models and compares their ability to describe and analyze the IT penetration process. Evolutionist theories occupy themeselves with the direction of change and its final goal while evolutionary theories are indifferent to direction and concentrate on the mechanisms which produce the change. The well-known Nolan's stage hypothesis provides an example of evolutionist explanations which classify historical events into stages. These stages succeed one another and lead to some 'end-state' such as 'maturity.' The transaction cost theory is offered as an example of an evolutionary explanation. It aims to reveal mechanisms that constrain or enforce organizational choices during the IT penetration. TCA analysis offers theoretical constructs to describe economic conditions that shape the organizational forms and the direction of IT penetration. We demonstrate the applicability of the TCA-based analysis by outlining two contradictory forces shaping the IT penetration process. This also explains why the IT penetration often brings about confusing and contradictory outcomes.

1 Introduction

Since the late 60's both the practitioners and academics have been concerned with how the penetration of information technology (IT) into organizations can be explained. By information technology we mean computing and telecommunication technologies and associated know-how to apply them in different fields of organizational activity. By penetration we mean organizational processes that unfold over time through which organizations adopt, accomodate and transform IT. A particular research concern has been to understand interactions between the extent and level of IT penetration and the organizational structures and processes that sustain and amplify it (Friedman & Corford 1989, King & Kraemer 1984). One conclusion from these studies has been that technical advances of IT forms only one factor that can explain the patterns of IT penetration.

This paper sets out into a task to discuss and compare models that describe the penetration of IT. These models usually frame the IT penetration as an organizational process of learning, economic rationalization, or competition over resources. Accordingly, such models do not explain the growth of computing by the technological imperative (Markus & Robey 1987) alone, but focus on the wider arena of conditions, organizational forms and IT application targets in explaining its pace and direction. Our goal is to characterize how aspects of IT penetration have been treated in the pertinent literature. We want to shed light on factors by which various IT penetration models explain the changes in the IT use and management. In short, the paper explores what we know and what we do not know of the evolution and selection of organizational strategies to deal with the IT penetration. The paper complements available analyses of the evolution of computing (Friedman & Cornford 1989, King & Kraemer 1984) by expanding these analyses with an institutional economic model of the IT penetration.

The paper is organized as follows. In Section 2 we introduce simple stage-models that classify the computerization levels into stages based on a single criterion or a set of criteria. This provides a backdrop to analyze in more detail the well-known Nolan's stage hypothesis in which the IT penetration is described as a linear learning process directed to mature forms of IT development and use. This is accomplished in Section 3. As an alternative organizational view of the IT penetration we outline in Section 4 an evolutionary transaction-cost (TCA) based model. It focuses on the economics of IT services and describes mechanisms that enforce the selection of alternative organizational arrangaments economizing the delivery and coordination of IT services. In Section 5 we synthetize weaknesses and strengths of different IT penetration models and suggest promising topics for future research.

2 Simple Stage-Models of IT Penetration

Research into the IT penetration has produced multiple taxonomies representing successive historical levels of computerization. Such models offer typically evolutionist explanations that aim to classify historical events and populations into disjoint eras or stages that succeed one another. The classification is usually made on the basis of a single criterion or several criteria (King & Kraemer 1984). Moreover they assume that the change is directional. The models serve mainly descriptive purposes and do not provide any accounts of mechanisms that push IT penetration from one level into another. In short, they are simple taxonomic classifications of the past experience. Therefore we call these models simple stage-models.

Simple stage-models have been developed from multiple viewpoints and for multiple purposes. In the following we will distinguish four types of simple models:

1. stage-models that classify the conditions of IT penetration,
2. stage-models that describe the forms and processes of IT penetration,
3. stage-models that classify the application targets of IT, and
4. multi-dimensional stage-models that combine two or more criteria from models (1), (2), and (3).

Stage-models in categories (1), (2) and (3) we call one-dimensional stage-models as they base the classifications of IT penetration on one criterion.

2.1 One Dimensional Stage-Models of IT Penetration

The penetration of IT into organizations depends on a number of necessary and sufficient conditions that make the penetration possible. Obvious examples are available computing platforms, or reliable infrastructure. The analyses that classify these *conditions of computerization* identify distinct developmental levels of IT or the growth patterns of other environmental factors. A typical description of computerization stages is based on computer generations distinguishing between eras of vacuum tubes, transistors, circuit integration, large-scale circuit integration, decentralized systems etc. (Withington 1974). Unfortunately, these models do not recognize internal factors in the IT penetration such as decision-making processes and structure, or external factors such as the availability of personnel.

Several simple stage-models focus on the *forms of IT penetration.* A rich variety such models are available: location of IS function, role of IS function, and types of IS development and management processes. One of the first stage-models in this class was to classify changes in the organizational location of IT activity (Ahituv & Hadass 1978, Ein-Dor & Segev 1980, Gildersleeve 1974, Davis & Olson 1985, Friedman & Cornford 1989). These analyses many times fall short of describing the internal mechanisms that have affected the organizational position of the IS function.

Another species of analyses describes stages in the *evolution of the role of IS function.* They claim that changes in the organizational location of IS function

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are a consequence of changes in the impact of IT on the organization. When the impact changes, the 'modus operandi' of the IS function has to change, too (Zmud *et al.* 1987). A typical stage-model of this sort is a three level model of IS management orientations (Hirschheim *et al.* 1987). The value of such models is that they show how the scope and direction of the impact of IT is reflected in the managerial strategies to cope with the IT penetration. These models lack, however, a in-depth analysis of the causes that change the impact of IT.

Classifications of IS development processes distinguish alternative managerial strategies for the development of IS (Humphrey 1988, Friedman & Corndford 1989, Somogyi & Gallier 1987). Typically these models recognize some recurrent patterns in the evolution of information systems development processes.[1] These value of these stage-models show is that they show how organizations learn to make IS development routine when their organizational importance grows. They are, however, inadequate to describe how changes in computing platforms and application targets affect the content and delivery mechanisms of IS products.

Some stage-models distinguish between changes in the application types of IT. An typical attempt to classify IT penetration forms from this point of view is the IS discipline model elaborated by Vepsäläinen (1988). He attempts to recognize alternative development *disciplines* that compile available technical platforms into different operational solutions. Widely practiced disciplines have been: routine integration, shared data, and service-oriented disciplines. The discipline based classification helps to trace the historical evolution of conceptual frames that have been deployed in the different stages of the IT penetration. It ignores, however, a wider institutional environment in which the disciplinary knowledge is maintained and applied.

All in all, one-dimensional stage-models single out mostly in an ad-hoc manner, some characteristic in the IT penetration and trace down its trajectory through different developmental levels. By so doing they offer insights into how computer platforms and solutions have evolved over the years, and how managerial and organizational strategies have matured. They lack, however, a more encompassing and detailed analysis of the interactions between various elements of computerization and the mechanisms that push organizations from one stage into another. In many cases they serve as post-hoc rationalizations of historical episodes, and their predictive capability is low.

2.2 Multi-Dimensional Stage-Models

In one-dimensional stage-models the IT penetration was divided into successive stages based on one aspect only. The next obvious step would be to combine these aspects or 'dimensions' into a more comprehensive single model. Such models we call multi-dimensional as they synthetize evolutions in several dimensions.

In multi-dimensional models the classification into stages is usually 'two dimensional': the stages form the rows and different dimensions of the IT penetration form the columns. The resulting model is evolutionist, as it does not delienate dependencies and interactions between the major aspects (dimensions) of the IT penetration; it mainly tabulates the stages of different dimensions within a single model.

The IS literature includes several multi-dimensional stage-models which differ mostly in the applied terminology. Interestingly enough, several researchers have ended up in factoring out three stages (Mason 1989, Somogyi & Galliers 1987). An example of a multi-dimensional stage-model is presented in Tables 1 and 2 after Somogyi & Galliers (1987). The tables divide the IT penetration process into stages using three major dimensions: conditions of the IT penetration characterized by the nature of technology, nature of systems operations and characteristics of information systems; the IT penetration forms characterized by the focus of systems effort and characteristics of systems development; and, the IT application types characterized by reasons for using the technology, type of applications, and the characteristic way of using the technology.

The tables indicate that during the IT penetration its conditions, forms and goals have evolved through specific stages as indicated by the vertical axis. The horizontal axis describes how changes in various dimensions are intervowen together to form specific stages that include organizational arrangements, technological platforms, applications types, and solution frames. Finally, as the IT penetration has intensified and diversified the IS function has climbed in the ladders of organizational hierarchy and power. Hence the multidimensional stage-models provide in a condensed form a holistic view of how various developments have been interlinked together and how they depend on each other. In this sense a multi-dimensional stage-model can serve as a valuable starting point for more systematic studies on the IT penetration and, help to shape management attention into the evolution of IT.

If we examine multi-dimensional stage-models critically, we can note that they do not explain how aspects of IT penetration interact. Neither do they clarify internal mechanisms which have pushed organizations towards increased computerization, nor do they reveal forces that have pushed organizations from one stage to another.

3 Nolan's Stage Hypothesis of IT Penetration

One problem with simple stage-models is that they do not provide any benchmarks to indicate the extent of the IT penetration on an organization wide perspective. Moreover, they do not recognize differences in organizational strategies to cope with different stages of IT penetration. The most well-known and widely debated model that attempts to overcome these weaknesses and analyzes IT penetration in an organization wide perspective is Nolan's stage-hypothesis.[2]

Nolan's stage theory is not a uniform theory but consists of a series of explanations (models) complementing each other. These models Nolan developed in co-operation with other researchers and he improved the model on several oc-

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ERA	REASON FOR USING THE TECHNOLOGY	CHARACTERISTICS OF INFORMATION SYSTEMS	TYPE OF APPLICATIONS	CHARACTERISTICS WAY OF APPLYING THE TECHNOLOGY
DATA PROCESSING	• ECONOMIES OF SCALES OF ADMINISTRATIVE OPERATIONS	• BATCH • STAND ALONE UNRELATED SYSTEMS	• SCIENTIFIC • COMMERCIAL: BACK-ROOM, ADMINI-STRATIVE SUPPORT	• AUTOMATION
MANAGEMENT SERVICES	• EFFICIENT OPERATIONS & CONTROL	• ON-LINE • REAL-TIME • INTERCONNECTED THROUGH DATABASES	• MANAGEMENT INFORMATION & CONTROL SYSTEMS • CORPORATE DATABASES	• MANAGEMENT SUPPORT • OPERATIONAL CONTROL
INFORMATION PROCESSING	• EFFECTIVE BUSINESS CONTROL & SUPPORT • STRATEGIC BUSINESS ADVANTAGE	• USER FRIENDLY • NETWORKED • MIX OF PRODUCTION SYSTEMS, MODELS AND WORKING PROTOTYPES	MIXED: • DECISION SUPPORT • USER MODELS • EXPERT SYSTEMS • ROUTINE PRODUCTION SYSTEMS & STRATEGIC APPLICATIONS	• BUSINESS SUPPORT • STRATEGIC WEAPON
TRENDS	Reducing costs ↓ Supporting the Business	Inflexible, Regimented ↓ Accommodating, Flexible	Operational ↓ +Tactical ↓ +Strategic	Technology Drive ↓ Business Need

Table 1: *Periods of IT evolution*

ERA	NATURE OF THE TECHNOLOGY	NATURE OF SYSTEMS OPERATIONS	FOCUS OF SYSTEMS EFFORT	CHARACTERISTICS OF SYSTEMS DEVELOPMENT
DATA PROCESSING	• CUMBERSOME MACHINES • LIMITED RELIABILITY • LIMITED INPUT/OUTPUT MEDIA	• CENTRALISED • REMOTE	• PROGRAMMING PROCESS	• EMPIRICAL
MANAGEMENT SERVICES	• LARGE MAINFRAMES • OPERATING SYSTEMS • SCREEN-BASED INPUT-OUTPUT • DATABASES • MINICOMPUTERS	• DISTRIBUTED PROCESSING • TRANSACTION DRIVEN OPERATIONS	• SYSTEMS ANALYSIS AND DESIGN • SYSTEMS LIFE CYCLE • INCREASING MAINTENANCE • DATA MANAGEMENT	• ANALYTICAL, STRUCTURED (separate trends for process and data) • PROJECT MANAGEMENT
INFORMATION PROCESSING	• CONVERGING TECHNOLOGIES • MINIATURISATION • PACKAGES • PCs/WORKSTATIONS	• USER/BUSINESS DRIVEN • INFORMATION CENTRE • BALANCE BETWEEN DISTRIBUTED/ CENTRALISED APPROACH	• INFORMATION MANAGEMENT • COMMUNICATION • END-USER INVOLVEMENT • LINK WITH BUSINESS STRATEGY	• PARTICIPATIVE • END-USER COMPUTING • PROTOTYPING • AUTOMATED TOOLS • IS PLANNING/STRATEGY
TRENDS	Fragmented ↓ Packaged & interconnected; addressing different forms of information (data, voice, text, image)	Unavailable, regulated ↓ Supportive, available	Technical Issues ↓ Business support Strategic issues	Ad hoc ↓ Methodical, social, business related

Table 2: *Periods of IT evolution (contd)*

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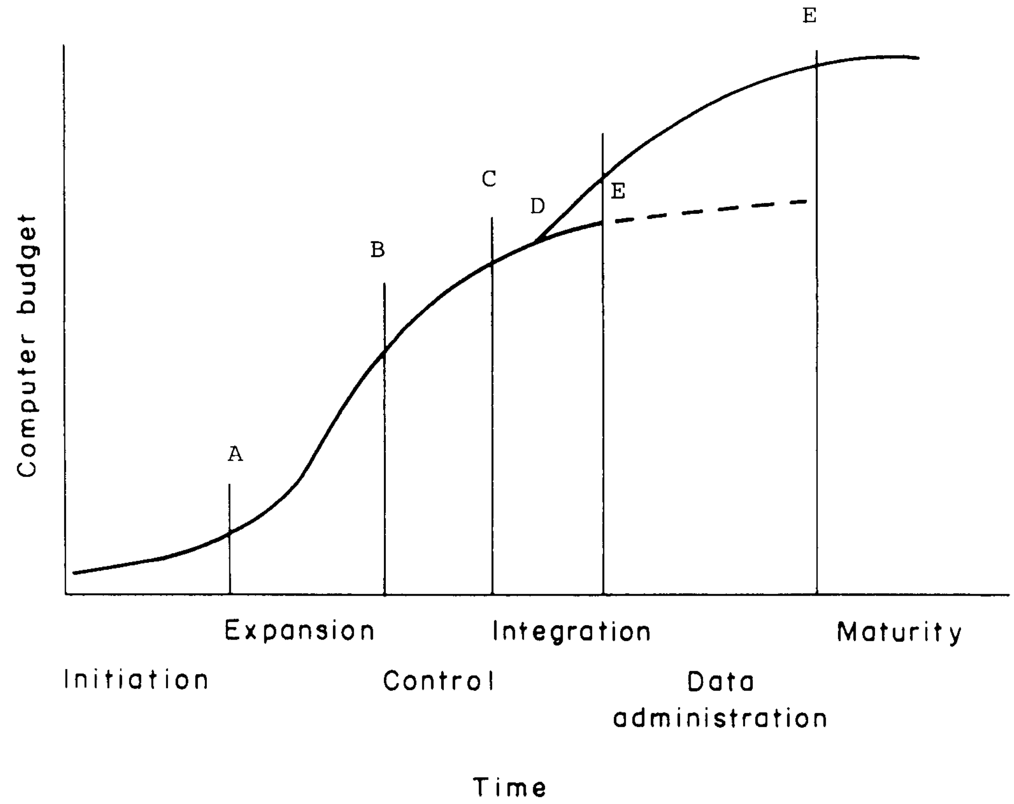

Figure 1: *Nolan's stage hypothesis*

casions on the basis of criticisms and gathered experience (Noland 1973, 1977, 1979, Gibson & Nolan 1974). Our intention in the following is to focus on the ways in which Nolan framed in his theory dependencies between the conditions, and forms of IT penetration and its application targets.

3.1 Basic Elements of Nolan's Stage Hypothesis

Nolan's theory starts from the conditions of computerization. He sets out to explain why the data processing costs (conditions) form a S-shaped curve (Figure 1) when the costs are presented as a time function. Nolan assumes further that costs can be used to describe a wide and rich array of features describing changes in data processing such as technical features, changes in company's areas of operation, company sales figures, organizational strategy, management practices and primary computer uses.

In the expense curve, the turning points A, B, and C divide the evolution of IS function into four different stages. Moreover, each stage is empirically testable and distinct. This distinction leads Nolan to make another central hypothesis: the turning points in the expense curve represent qualitative transition points in the evolution of the IS function i.e. in the IT penetration forms and targets. Thus, each stage: origin-A, A-B, B-C, C-onwards, is characterized by certain application types, a development discipline (application targets), a management strategy, and a user control mechanisms. Accordingly, Nolan developed a set of benchmarks that helped to identify distinct stages. These were: applications portfolio, resources, management and user awareness. In this way Nolan binds together simple stage-models in a unique manner which also helps to measure the level of IT penetration using the IT cost figures.

Nolan's stage-hypothesis goes still further. It reveals also how interactions between dimensions of computerization can be explained in a dynamic manner. Nolan claims that the analytical relationship between the precedessor and the successor stage must be well defined. If we examine the model in reverse order, we can discover how this requirement is met in his model. Nolan's argument is that the activities in the IS development (design, management, organizational approach) and application types differ in each stage. These differences are determined by the conditions of IT penetration which are mirrored in the cost curve. The cost curve, in turn, is shaped by continuous technological innovations (such as introduction of cheaper computers or of new functionalities, e.g. data base management systems) that permit organizations to expand their computer uses. Nolan claims also that these technological innovations are accomodated by managerial reactions so that every point in the budget curve and its shape is an outcome of management reactions to technical changes which push organizations ahead in the IT penetration. Thus, each stage represents a 'level' of the IT penetration in which different dimensions of the adaptation process are synchronized both 'horizontally' along different dimensions and 'vertically' along different stages.

Later on Nolan claimed that changes in the cost curve were foremostly caused by continuing advances in IT and that these technological changes laid continually the basis for the outgrowth of new S-shaped curves (Figure 1: D-E) (Nolan 1979). Hence, the S-shaped curve represents a causal relationship between a technical change (cause) and management reactions (effect). Later on this view has been extended by Cash *et al.* (1988) to cover any new distinct technologies (such as expert systems, telecommunications etc.). Moreover, Gurbaxani & Mendelson (1990) point out that the S-shape curve is, in fact, an integral of a bell-shaped function that has been used to characterize the diffusion of new technologies over time. Thus the S-shape curve depicts the expected amount of IT adopters (and costs) as a function of time.

The stages recognized in the S-shaped curve are summarized as follows after Nolan (1973):

Initiation: (Origin - A). Computer use satisfies basic needs; slow increase in

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use; computerization problems arise; management only slightly interested in solving the problems; minimal planning.

Contagion: (A - B). Rapid increase in the use of computing, because the management is committed to promoting technology. Users' expectations increase; management seeks to control the growth; centralization begins; more planning.

Control: (B - C). The management controls the costs; priorities in planning; data processing is centralized; the position of IS management in organization is acknowledged; standardization; charge-back mechanisms to control the growth.

Integration/Maturity: (C - E). Re-evaluation of control and increase in experimentation; planning widely accepted; user knowledge increases; use and application development rationalized (expense awareness); application development is decentralized; centralization/decentralization is controlled with business strategies; slow increase in costs.

Nolan's (1979) interpretations of the S-shaped curve appeal thus to evolutionist explanations typical to stage-models: organizations move towards more mature forms of IT adaptation. The maturing process is an an outcome of complex interactions between dimensions of IT penetration. Yet, the primary driving force behind the maturing process is technical innovation. In the model the expense (vertical) axis indicates the degree of penetration of technology, and the (horizontal) time axis shows the technical progress of information technology. The shape of the expense curve represents management reactions to the increased potential of the technology. Though organizations can be at different stages in learning curve, they all move towards a mature management of technology. Consequently, in his last writings, Nolan interpreted his model in a normative way: the S-curve indicates how the management should control the penetration of IT during different stages.

3.2 An Assessment of Nolan's Stage Hypothesis

Because Nolan's stage-hypothesis is well-known, and Nolan claims that his theory is general and empirically valid (Nolan 1985)[3] the validity and predictive power of this theory has been tested perhaps more than any other theory in IS (for a good review see Lee 1990 and King & Kraemer 1984). Unfortunately empirical studies have shown the dubious validity and poor predictive power of the stage hypothesis (see King & Kraemer 1984, Benbasat *et al.* 1984, Lee 1990). The conclusions from these studies can be summarized as follows:

1. The expense curve cannot be used as a measure to aggregate a wide array of variables, and data processing budgets do not develop in an S-shaped way but mostly linearly.

2. The stages are not in fact independent so that they would describe different ways in which the organization react to technology.

3. Information management (maturity) does not so much describe the technical maturity of the organization but its financial capacities to invest into IT.

4. Organizations which apply the so-called 'mature' computing policies face the greatest problems. Thus 'maturity' is a dubious term.

5. The adaptation to technology is not only defined by changes in technological push, but also by the fluctuations in demand, which are partly due to random factors (companies overinvest in information technology for taxation and other reasons) and partly due to a real increases in computing needs.

6. It is not easy for the organizations to adapt even to 'mature' technology, and the changes in 'routines' to deal with mature technologies are not necessarily succesful. There are many grim stories of failure to prove this point.

7. The model argues that organizations follow the stategy of constant technological change. However, in practice, organizations adapt to IT in investment cycles and most of the time they just repair and polish the already existing technological base.

The empirical misfit of Nolan's stage theory with the realities of IT evolution are thus obvious. Many of these can be well accounted the evolutionist assumptions underlying his theory:

1. It is a *finality* theory. The computing within an organization develops through a number of stages toward the highest stage which Nolan called maturity. Nolan does not give any detailed grounding for choosing an evolutionist postulate (see King & Kraemer 1984). In his article Nolan (1985) refers on a general level to the instrumental usefulness of evolutionist models during the formative periods of diverse fields, and provides as good examples biological growth, economic growth and galaxies.

2. It is a *universal* theory. All organizations at all times follow this model. It is interesting that when organization theorists started openly to discuss the significance of contingency theories in organization studies (see e.g. Perrows 1986), Nolan at the same time presented a universal theory on the development of one of the focal organizational functions.

3. It is a *mechanistic* theory. Nolan assumes that the organizational units delivering IT services, as well as the organizational units exploiting them, remain unchanged during the different stages —- only the quality and volume of computing increases. This explains also why Nolan limited his focus merely on the budget growth of the data processing department, even

though it only covers a small fraction of the total computing costs in the organization (Strassman 1976).

4. It is a *one-directional* theory. On the one hand, it assumes that the technical changes (cause) have an impact on the goals of data processing and the forms of computerization (effect). On the other hand, the forms of computerization do not seem to have impact on the goals of computerization and thereby on the technical demand (the conditions of IT penetration).

5. It is a *one-dimensional* theory. Nolan examines changes that have taken place in the IS function only as an outcome of technical change. For example, organizational changes, competion over alternative resources, the company's position in the competitive market or its own adaptation mechanisms to computing do not have any impact on the forms of IT penetration. The theory tells us even less as to why organizations need to adapt to new technology and which forces push them upward on the learning curve. Technology is conceived as an external force which develops on the basis of its own logic and forces organizations to behave in a certain way. Nolan does not provide any substantial answer as to why organizations are willing to spend their scarce resources into computing.[4]

In summary, we can state that though its enormous intuitive appeal, Nolan's stage hypothesis is not a sound theory to understand and explain the developments of computing.[5] It has an evolutionist bias that leads to ignore mechanisms that bring about the change, it reduces developments into technological factors alone, and treats both the internal organization of the IS function and the external environment of IT services in a mechanistic manner.

4 Evolutionary Models of the IT Penetration

4.1 The Concept of an Evolutionary Model of the IT Penetration

Simple stage-models do not account for dynamic interactions between computerization and organizations. Even, the most serious attempt to explain these interactions using evolutionist terms, Nolan's stage hypothesis, fails to describe IT penetration mechanisms. We believe that one reason for this is the evolutionist raison d'être in these models that attempts to makes the reality to fit into the model and not the other way round. The second reason is the technological determinism inherent in Nolan's model that explains the IT penetration by simple technological changes, but leaves untouched what is delivered by these technologies and how.

For these reasons, we believe that there is a need to shift the focus on larger environmental changes and mechanisms that make differences in the IT penetration possible and necessary. In short, we should aim at *evolutionary* explanations which occupy themselves with describing mechanisms and processes by which change occurs. Evolutionary IT penetration models should therefore be more careful and delicate in understanding what is changed during the developments. Overall, there is a need to move the research focus from a coarse technological categorization into a more detailed description of various services (IT services) that are 'packaged' around available technological platforms over a variety of organizational conditions.

In evolutionary models the changes in dimensions of the IT penetration form cyclical dependencies. For example, the changes in IT services influence the 'host' organization which affects back to the content and form of expected IT services. Thus, evolutionary models perceive the IT penetration to be an outcome of attempts to maintain a balance in between different dimensions of IT penetration (state). Threaths to this balance surface whenever changes, either intentional or accidental, in the dimensions of IT penetration take place. Such dimensions include technical platforms, organizational arrangements that govern IT service delivery, applied disciplines, or major environmental changes such as large organizational restructuring, take-over etc. Attempts to restore this balance result in a new balance (state) and cause new IT developments. The main focus is here in understanding processes and mechanisms through which the actual developments take place and these understandings must be founded on adequate theoretical accounts of organizational and economic behavior which surround the IT penetration. This connection is largely missing in the evolutionist theories as they mainly explain penetration by the technical factors.

In the following we shall embark upon analyzing one evolutionary alternative to explain the IT penetration. This is the institutional economics model or transaction cost model (TCA). We present some basic elements of the model and draw some conclusions on how it can explain the dynamics of IT penetration. The TCA model seems to be a good canditate to analyze the economics of the production and delivery of IT services as it permits to analyze stability conditions over a set of IT penetration processes and to explain their internal evolutionary selection mechanisms. This sort of analysis offers a lot a promise as it can overcome some of the deficiencies in Nolan's stage-hypothesis including: its evolutionist appeal, one-dimensionality and the mechanistic view of organizational arrangements.

4.2 Institutional Economic Models of IT Evolution

The transaction-cost theory (Williamson 1975, 1985) has been developed during the 1970's and 80's, and it aims to find economically optimal ways for organizing. The theory claims that the economics of any exchange of products and services is determined by the production costs and the transaction costs. Whereas the neoclassical economics have concentrated on the economic stability conditions of production costs and assumed that markets are costless, the transaction cost theory tries to analyze the costs of exchanges and how these affect the economics of organizations. In the IS literature it has so far been applied to analyze the impacts of IT on the organizations' size and structure (Gurbaxani & Whang 1991), optimal project organizations (Beath 1983), to find out potential benefits of interorganizational IS (Suomi 1990), to develop generic IS architectures (Ciborra 1987), and to develop group based applications (Sørgaard 1988). In this paper we shall discuss the penetration of IT from the transaction cost perspective.[6] To our knowledge this is one of the first attempts to describe IT services from such a perspective, though Gurbaxani & Kemerer (1990) have a similar goal when they discuss the organizational ramifications of agency theory to End-User Computing.

Instead of analyzing the IS function as a technical resource as suggested in Nolan's stage-hypothesis the transaction cost theory sets out to examine the costs of transacting *IT services*, optimal governance structures for such services, and the production costs of services. By IT services we mean activities that involve anticipation, specification, design, implementation, or production of computer based operations. Though IT services may be supported by some tangibles what is purchased is the performance rendered by one party for another. Services, as compared to manufacturing (such as data processing operations in a large computer center) are (1) mostly intangible, (2) represent the closeness of the consumer to the product, and (3) are expected to change the state, attitudes or behaviors of the customers (Parker & Benson 1989, Apte & Vepsäläinen 1987). IT services thus involve exchanges between two or more agents. Examples of IT services are consultation activities to design an IS architecture, activities to specify an information systems, or a purchase of a word-processing package. By transaction costs of IT services we mean costs incurred due to efforts to anticipate, specify, control, coordinate or monitor IT services. By a production cost of an IT service we mean its labor costs (manpower) and capital costs (computer facility).

In the TCA-based analysis features of IT services that affect their transaction costs are examined and also reasons for their variation (change). We also investigate how services get defined, provided, and monitored between parties involved, what alternative governance structures are available to organize the services, and what are their economical effects. The advantage of the TCA-based analysis is that it does not postulate that technological changes themselves would have any real economic imapct. Instead, the focal point of the analysis is understanding those exchanges where different parties meet to develop, negotiate, produce or monitor IT services that are expected to meet some user needs, and what are the costs of producing these services.

Computers and other technical innovations form thus only one necessary means to develop and to deliver IT services. Others include e.g. technical skills, agents' knowledge and ability to express their needs and expectations, agents' visions and skillfulness to utilize service and so forth. Accordingly, the major driver behind the IT penetration in Nolan's theory — technological change — has in a TCA analysis a different status. It introduces mainly twofold impacts.[7] First, they can be seen to lower the production costs and thereby to decrease the total costs of IT. Second, they can change the contents of IT services and thereby increase the transaction costs of IT services (as the difficulty and effort to define and coordinate IT services increases). These two factors together affect the total economic efficiency of the IT services when technological innovations occur.

4.3 Transaction Costs in IT Services

According to the TCA analysis IT services can be classified on the basis of their performance ambiguity and opportunism. The performance ambiguity denotes the agents' difficulty to measure or to define services and assess their economic value. The opportunism denotes agents' capability and willingness to pursue their interests, for example, by destroying or hiding information. The TCA theory claims that for each complexity/opportunism combination there is an optimal transaction governance structure, i.e. an organizational form which organizes the exchange in the most economic manner.

Performance ambiguity can be analyzed according to four characteristics: asset specificity, uniqueness, complexity, and uncertainty. Asset specificity means that the resources to be invested in transaction are applicable only in a narrow area i.e. their next best use value is significantly lower. Thereby it is a source of considerable transaction cost since special attention is required to prevent the other parties to act opportunistically after the investment has been made. For instance, if an information system project requires the acquisition of a specific computer environment, it has a high asset specificity. The uniqueness of a transaction means that the IT service is new, or unknown. If, for instance, a completely new, tailor-made IT service such as a new IS is designed, it is defines a unique transaction. In such a situation, it is very difficult for any of the parties involved to define the economic value of future exchanges which requires institutional mechanisms to ensure the rights of different parties thus increasing transaction costs. The complexity of the transaction arises from the difficulty to define precisely the IT service requiring specific investments to guarantee the correctness of the specification and thus increasing the transaction costs. IT services involve usually high complexity because the characteristics of the service are difficult to define beforehand and they depend on a number of unpredictable interactions between several factors (the equipment, programs, users etc.) Uncertainty arises from the difficulty of the parties to foresee contingencies to deliver the IT service because of, for instance, problems in designing and timing the service. For example the implementation of IT services involves often high uncertainty as seen in high failure rates, escalating development expenses etc.

Many IT services are characterized by a high performance ambiguity. They are also characterized by a high degree of opportunism, since the parties have a low goal congruence and high information asymmetry. It is difficult for one party to estimate the true contribution of other parties.

In a situation where both the opportunism and the ambiguity is high the transaction cost theory would predict that IS function will before long become centralized (as Nolan's model presumes). This conclusion is valid, if all central components of the IT service will remain stable including performance ambi-

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guity, opportunism, and production costs. There are, however, several forces which impact this balance. In the following two opposing forces are delienated which surface the dynamic nature of the IT penetration and different mechanisms through which IT services get organized in different situations. These are: the decreasing relative complexity of IT services, and the proportional increase in transaction costs among all IT service costs.

4.4 Decreasing IT Service Complexity

The decrease in the IT service complexity implies that transaction costs per service decrease. This is a natural result of efforts to reduce service-specific costs and, thus, to lower the threshold to apply computer applications. It signals the learning of parties involved in designing and monitoring continually the IT services. In this sense the stage models that describe evolutions in the managerial strategies to cope with the complexities of IS development are one example to summarize these developments. As the models also point out, this is a natural tendency because the total costs of the IT service are decreased through rationalizing and streamlining the activities that define and monitor IT services. Standardized software packages provide a case in point in describing decreased service complexity. Using standardized software packages the costs that incur due to specifying and implementing the software per an installed application is drastically reduced.

Constant decrease in the IT service complexity makes it possible to expand the demand for the growing production (and capacity) of computers. Otherwise only organizations having a high resource slack would be able to invest into IT services because of their very high transaction costs. For the large majority of organizations such services become economical only when their specification and development becomes routine and standardized.

During the evolution of IT the complexity of IT services has been lowered through several means. These include: decreasing asset specificity (open and tranportable applications, standardized user interfaces), decreasing uniqueness through the standardization of applications (turnkey applications, the standardization of interfaces such as EDI or X.400), decreasing uncertainty (specification methods, use of prototypes) etc. In the long run, this has changed the IS function from a unit delivering tailor-made, but narrow services (causing high transaction costs with high asset specificity) into a service function having a broad but more standardized, and relatively well defined service structure (having lower asset specificity and lower transaction costs per transaction).

Accordingly, the economic basis of controlling IT services has changed. Hierarchy has been replaced in many cases by more market like structures as described by the phrase "a business within a business" (Zmud *et al.* 1987). As a consequence, the IS function as an independent organizational unit will shrink. Maturity would soon turn into death

4.5 Higher Transaction Costs among All IT Costs

If we start to examine changes in both the transaction costs and the production costs, we can observe that the proportion of transaction costs among all IT costs tends to increase. The rationale is the following: if computing (production) costs are reduced while transaction costs increase, organizations can change their leverage of IT services, even if they do not invest more in IT. Assuming that all other factors remain the same the complexity of IT services will increase constantly and thereby the share of transaction costs will grow. This seems to have happened in a constant pace during the last two decades. While the costs of computing for the same service have decreased by the 20–30% a year, the organizational costs to arrange, specify and monitor the growing variety of IT services has increased constantly. Moreover, affluent companies head first in this direction because due to their great volume of IT spending they are able to reap more benefits from the considerable reductions in the production costs (Gurbaxani & Whang 1991). The new expanded sets of IT services often benefit organizations, e.g. by gaining competitive advantage. Success stories in expert system applications or telecommunications prove the point here. This, for its part, increases organizations' willingness to invest further in IT and to actively search for opportunities to expand their IT services. Growth in the IT related services result consequently in the growing performance ambiguity (in terms of complexity, uniqueness, and uncertainty) pushing the organizational arrangements of IT services towards hierarchic governance structures that can economize high levels of opportunism and ambiguity.

In the long term, this development seems to support Nolan's opinion of the central role of the (hierarchical) IS department in delivering IT services and of the associated patterns of growth in IT costs. It is likely, however, that this tendency realizes only when there is a 'need' for novel applications made possible by technological innovations. It is not likely to occur when services mature and are being streamlined, there are no new technological innovations in sight, or the organizational slack to carry out high transaction costs to specify new services is not available. In this case also the conclusions drawn by Nolan would not hold, i.e. there are no clear 'stages', the stages are not 'independent', and the IT penetration is not defined by technological push alone.

We find evidence for this development, as well, if we examine some of the most recent changes in the organization of the IS function. For example, many companies have moved the responsibility of the technical implementation of some of their IT services to outside vendors. This aims at lowering the implementation costs (and production costs) due to improved economies of scale and scope, but simultaneously increases transaction costs needed to specify and monitor IT services (more time and money will be spent on specifying applications and on their organization-wide planning) and their implementation contracts. In this case though the costs of IT remain on the same level, they are not directed through the IS department, and the variation of the IT service will probably increase.

4.6 Summary of the Institutional Economic Analysis

In summary, we observe that on the one hand the relative increase in the transaction costs pushes organizations towards increased computerization as long as there is a proportional decrease in the production costs and the significance of new IT services is acknowledged by the organizations, i.e. if th e organizations are willing to maintain the same IT spending level despite reductions in the production economies. In this situation also Nolan's argument would hold, but only to organizations that meet the requirements of having enough organizational slack, willingness to invest in IT and so forth. On the other hand, agents' learning rationalizes and streamlines continually the existing service base and implies substantial changes in the proportional efficiency of alternative delivery channels. This, in contrast, would lead to developments that are inconsistent with Nolan's model. Because the two developments are opposing and they have a simultaneous impact on the economics of organizing the IT services it is no surprise that support for Nolan's theory is contradictory.

The analysis must also recognize that different organizations are in a different position with respect to the two developments. This depends among other things on their strategic choices, their abilities to seek and apply IT services and on the general structure of their industry. Therefore, varying impacts of the two developments on IT penetration need to be examined on a case by case basis. Accordingly, the transaction cost model does not make any universal evolutionist claims which would apply to the IT penetration in all organizations, nor does it accurately predict what will happen in a specific situation.

Some caveats need to be made to our discussion. First our analysis is here only preliminary and not supported by any thorough empirical study. In addition, the TCA based analysis involves still a number of application problems: first the concept of IT service needs to be defined more carefully and it should be augmented with a value-chain analysis to provide more systematic understanding of value-adding acitivities in the IT service; second the level of analysis may be too detailed in describing a larger scale change; third the TCA analysis does not suggest means to economize organizational change (what are the cost of tearing down hierarchies and would those in charge really want to do it?); fourth there are weaknesses in operationalizing the concepts of transaction and transaction costs (Perrows 1986).

5 Conclusions

In this paper we discussed models to understand the IT penetration into organizations. First, several classes of simple stage-models were described. These models are mostly useful in classifying some interesting and pervasive aspects of the IT penetration process such as technological platforms, managerial strategies or applied cognitive disciplines. They do not necessarily provide any clues as to why these stages should or could occur.

Second, we showed how several stage models were synthetized in Nolan's stage hypothesis in an eloquent manner. Nolan also provides an attempt to describe why these stages follow each other, and also why they should follow each other. In addition, Nolan's stage hypothesis offers a simple mechanism to identify stages by the IT budget growth pattern with associated benchmarks. Despite its attractiweness and popularity Nolan's model is fraught with many empirical and conceptual anomalies. The most serious of them, we believe, is the evolutionist appeal that underlies it. This compels Nolan to describe the IT penetration as a maturing process in which the IT function grows in importance, size and variety of outputs as an outcome of continuous technological innovations (technology push), but yet the organization and impact of the IS function remains the same. At the same time IT management becomes mature and it is controlled in a frictionless and efficient manner through a hierarchic governance structure. Hence, the evolutionist thinking leads to ignore selection mechanisms that direct organizations to choose between alternative paths of development of IT service and instead forces to fit the reality into the model.

Third, as a conclusion, we noted that better accounts of IT penetration can be achieved by evolutionary models that focus on the selection and enforcement mechanisms of particular arrangaments of the IT service. By focusing on packaging the IT service we can better tie together technological, organizational and behavioral issues that are intervowen in the IT penetration process. As an example of evolutionary models we developed an institutional economic model of the IT penetration which analyzes the impact of the growing service complexity and the decreasing production and transaction costs on the IT service delivery mechanisms. This leads to conclude that Nolan's model can be helpful in describing the IT penetration process only under specific circumstances and that under different circumstances a very different development pattern would realize.

Despite its attractiveness our preliminary analysis has several limitations. These include the difficulty to operationalize the concept of a transaction cost, rigid economist assumptions of agents' behavior and the neglect of costs that are caused by organizational changes. Therefore, the TCA analysis is not necessarily suited for detailed case studies. It seems to be more applicable in the study of larger populations and investigations of the developments in the IT industry. TCA can also help to draw normative guidelines for the management and development of IS function. One area in need of suitable normative prescriptions is the outsourcing problem within the IS function.

In more organization specific investigations of the IT penetration we need theories which offer a rich pool of concepts to describe organizational changes over time. In understanding such episodes political interest and opportunism, hidden and visible resource bases, and symbolic universes that provide negotiation power, play a prominent role and must be taken into account. Also the sheer randomness of behaviors and events due to agents' bounded rationality must be recognized . The most promising of such theoretical bases seems to be the political models of organizational behavior (Pfeffer 1981, March & Olsen 1976).

Acknowledgements

Thanks go for Jaana Astala for translating the first draft into English. The author has also benefitted from constructive discussions with John Leslie King, Ari Vepsäläinen, and Allen Lee. Also two anonymous referees provided several constructive suggestions.

Notes

1. These include observations of how organizations proceed from individual experimentations with technology into tighter planning and formal supervision; and how managerial strategies are outcomes of efforts to balance bipolar elements in the development processes such as: slack versus control, discipline versus creativity, or technical focus versus organizational focus.

2. Nolan's stage theory was first published nearly two decades ago (Nolan 1973). In his first papers, Nolan presented the stage theory as agrowth hypothesis for the data processing function. Later he made several adjustments to his theory and discovered that his theory was empirically grounded (Nolan 1979). In most recent publications Nolan has reinterpreted the stage hypothesis in normative terms: the theory not only presents how IS function *changes*, it also prescribes the ways in which it *should be changed.* Excellent historical accounts of Nolan's theory can be found in (King& Kraemer 1984, Friedman & Cornford 1989).

3. In his article from 1985 (p. 196) he writes: "To date the theory has been supported in studies conducted by universities, IBM and Nolan, Norton & Company." He refers to studies conducted by Lucas & Sutton (1977) and Goldstein & McCririck (1980) as examples of supportive studies. Unfortunately, the outcomes of these studies are most disappointing evidence to corroborate the theory. Though the studies found mildly favorable evidence in the sense that the obtained budget data fitted into the S-curve shape in a statistically significant way (some or all coefficients were significant at the level of 5%), this result was quite dubious. In the Lucas & Sutton study some other curves such as linear curve and exponential curve were fitted to the data and using these models the b coefficient was statistically significant at the level of 5% in almost every case and the adjusted R^2 values were good. Hence these cost-models could explain the IT penetration costs at least as well. Also Goldstein & McCririck found what they called contradictory evidence in the sense that R^2 values were low and only few of the regression coefficients were statistically significant (5 out of 13). Also, Nolan's own contribution to the testing is questionable — for instance budget information was drawn from his own experience in consulting in 200 firms and it has never been published.

4. Nolan presents only institutionalized charge-back policies or increased user awareness as reasons to economically justify computing decisions. These are clearly insufficient.

5. As Lee (1990) notes the wide popularity of Nolan's theory is not due to how it speaks the truth of the developments, but how it speaks to those in 'control' of developments. In other words, a much interesting scientific research problem would be: "how Nolan's stage hypothesis as understood and used by IS managers makes

a difference to the ways in which they structure and solve real-world problems in the management of information systems" (Lee 1990, p. 24).

6. In this paper we are interested in the transaction costs of IT services, not in the transaction costs of 'major' business transactions. Though the latter problem is more fundamental and explains from an economic point of view major drivers in the penetration of IT, we believe there is also motivation to explore the former question independently. First, as IT is regarded "a business within the business" (Zmud *et al.* 1987) an economic analysis of different delivery mechanisms of variuos IT services is necessary: Second, the economic analysis of IT services can also teach something about the transaction costs of business transactions. Third, we believe that changes in the transaction costs of IT services affect fundamentally also the contents and economics of business transactions, i.e. the economic analysis of the former is one prerequisite for the economic analysis of IT. Finally, we believe that at this stage the analysis of the business transactions and the IT services simultaneously is a too difficult task.

7. If we extend the analysis with an agency-theory perspective there are also other impacts like agents' attempt to sustain and withhold critical technological skills, agents' attempts to maximize their prospective gains by maximizing their market value etc. (see Gurbaxani & Kemerer 1990). These are not discussed here further.

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